DOE/EA-0083

ENVIRONMENTAL ASSESSMENT

Solar in Federal Buildings Demonstration Program

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U.S. DEPARTMENT OF ENERGY

Assistant Secretary for Conservation and Solar Applications

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PREFACE

This environmental assessment (EA) of the Solar in Federal Buildings Demonstration Program has been prepared in accordance with the National Environmental Policy Act of 1969, as amended (NEPA) (42 U.S.C. Section 4321 et seq.). The EA follows applicable policies and procedures for compliance with NEPA set forth in 10 CFR Part 208 (41 FR 4724; January 30, 1976).

This EA analyzes the environmental impacts of the Solar in Federal Buildings Demonstration Program established by Title V, Part 2, of the National Energy Conservation Policy Act (NECPA) (P.L. 95-619, 91 stat. 3275).

I. DESCRIPTION OF THE PROPOSED ACTION

Title V, Part 2, of the National Energy Conservation Policy Act (NECPA) (P.L. 95-619) established the Solar in Federal Buildings Demonstration Program. The purpose of this Program is to stimulate growth and technical improvements in solar energy technology through the installation and demonstration of solar water heating and solar space heating and cooling (solar energy systems) in buildings owned in whole or part by the Federal Government including buildings occupied under a fee simple lease-acquisition contract.

The Program's goal is to be accomplished by providing technical and financial assistance through interagency agreements to implement approved proposals for the installation of solar energy equipment in Federal buildings. Assistance is limited to the design, acquisition, construction, and installation of solar energy equipment. NECPA requires that the U.S. Department of Energy (DOE) shall promulgate by rule:

"(A) requirements under which Federal agencies shall submit proposals for the installation of solar energy equipment in Federal buildings . . . , and

(B) criteria by which the proposals under subparagraph (A) will be evaluated, which criteria shall provide for the inclusion in each proposal of a complete analysis of the present value, as determined by the Secretary, of the costs and benefits of the proposal to the Federal agency, and for the demonstration, to the maximum extent practicable, of innovative and diverse applications to a variety of types of Federal buildings . . . and for location of demonstration projects in areas where a private sector market for solar energy equipment is likely to develop. (NECPA Section 523(a)(1))."

These requirements are set forth in the Department of Energy (10 CFR Part 436, Subpart D), Federal Energy Management and Planning Programs, Proposed Rule for Solar in Federal Buildings Demonstration Program (hereinafter Proposed Rule).

DOE is also required (under NECPA Section 523) to evaluate, in writing, each proposal pursuant to criteria developed under Section 523(a)(1)(B), and to obtain from participating agencies a life-cycle cost analysis in accordance with the Federal Energy Management Program's life-cycle cost analysis (as required in NECPA, Title V, Part 3). If the solar energy equipment is not the minimum life-cycle cost alternative (in accordance with Section 523(a)(6) of NECPA), the participating agency(ies) must indicate the amount by which the life-cycle cost of the solar energy equipment exceeds the minimum life-cycle cost (utilizing methodology and analysis procedures set forth in the Proposed Rule, 10 CFR Part 436, subpart A). This information regarding cost effectiveness will be compared with data from other similar proposed solar projects to assist in ranking all solar projects for final selection (as required by Section 436.78(c)(5) of the Proposed Rule). Life-cycle costing data for a proposed solar project will not alone result in rejection of the project. In addition, Section 523(a)(4) requires Federal agencies to periodically report to the Secretary such information as they acquire respecting maintenance and operation of the solar energy equipment involved, as stated in the Proposed Rule.

The Solar in Federal Buildings Demonstration Program is a three-year initiative affecting no more than 500 buildings out of a total of approximately 402,000 Federally owned buildings (or less than one percent). The anticipated budget levels for Fiscal Years 1978, 1979, and 1980 are $20.0 million, $25.7 million, and $23.5 million, respectively. Through Fiscal Year 1979, $45.7 million has been appropriated. The Act authorized a maximum of $100 million to be appropriated through the Fiscal Year ending September 30, 1980.

DOE, in conjunction with the U.S. Department of Housing and Urban Development (HUD), the U.S. National Aeronautics and Space Administration, the U.S. Department of Defense, the National Bureau of Standards (NBS), and other Federal agencies, has been involved in the demonstration of solar energy for water heating and space heating and cooling since 1975. Under the National Solar Heating and Cooling Demonstration Program, DOE is funding the installation of over 900 solar systems affecting approximately 11,500 residential units[1] and approximately 270 commercial solar projects.[2] In addition, there is a HUD/DOE hot water initiative involving ten states which will affect an anticipated 10,000 residential units.[3]

The evaluations and experience generated from these demonstration programs have been taken into account in this environmental assessment. Project experience information will continue to be made available from existing programs providing additional data to be drawn upon in the administration of this Program.

II. DESCRIPTION OF THE AFFECTED ENVIRONMENT

Solar energy heating and cooling technologies show potential environmental impacts in eight categories.[4] The impact categories include (1) air quality, (2) water quality, (3) land use, (4) ecological impacts, (5) structural impacts, (6) aesthetics, (7) social and institutional impacts, and (8) material resource requirements. Table I provides an overview of these environmental concerns and methods of deterring potential problems. These concerns are analyzed below, and mitigating measures are discussed at the end of each section.

Most of these areas are similar to those in traditional heating, ventilation, and air-conditioning (HVAC) building activities. Thus, in many instances, the standards and criteria for traditional HVAC equipment are applicable to solar energy technology. Relevant environmental concerns for solar heating and cooling systems in residential and commercial buildings were addressed by the NBS Interim Performance Criteria (IPC) for Solar Heating and Cooling Systems[5,6] and by the U.S. Department of Housing and Urban Development Intermediate Minimum Property Standards (MPS) for Solar Heating and Domestic Hot Water Systems.[7] The environmental and safety considerations for solar heating and cooling applications are also summarized in a National Bureau of Standards report.[8] The criteria, standards, and considerations referenced above were developed to provide specific guidelines for technical performance for use by solar designers, manufacturers, and builders; to define levels of performance for evaluation and procurement; and to provide a basis for the continuing development of definitive performance standards and criteria as solar energy technologies mature. Section 436.76(b) of the Proposed Rule requires an agency submitting a proposal to assure compliance with the IPC and MPS standards and criteria or to present an explanation satisfactory to DOE for a proposed exception thereto. Continuous monitoring by the Federal agency is required by Section 436.80 of the Proposed Rule to ensure effective implementation of Program standards.

Based upon historical experience and data from the National Solar Heating and Cooling Demonstration Program, the potential environmental effects listed in Section III below constitute the major areas of relevance to this Program. Table I[4,9,10] presents a comprehensive overview of these concerns, and strategies by which they can be mitigated or eliminated.

TABLE I

POTENTIAL ENVIRONMENTAL CONCERNS[4,9,10]

POTENTIAL ENVIRONMENTAL CONCERNS	STRATEGIES TO MINIMIZE OR ELIMINATE CONCERN
A. <u>Potential Air Quality Impacts</u>	
1. Outgassing	Allow for proper atmospheric dispersion.
a. Insulation	Use proper insulation, selection of materials, and pretreatment of insulation when applicable.
b. Fire conditions	Coordinate start-up time of system to closely follow installation. Follow IPC and MPS fire safety and materials standards. Adhere to local fire ordinances. Utilize proper firefighting equipment.
2. Auxiliary Unit Impacts	Apply conventional emission controls. Employ policies which stress energy conservation and efficiency.
B. <u>Potential Water Quality Impacts</u>	
1. Potable Water Contamination	Use double-walled heat exchangers. Employ effective, nontoxic, heat transfer fluids/storage media (studies ongoing).* Adhere to IPC and MPS equipment, systems, and materials standards.
2. System Flushing and Disposal	Follow IPC and MPS guidelines for proper system design. Utilize test results from studies on the impact of effective chemical loads on sewage treatment facilities, potable water, soil, vegetation, and groundwater (studies ongoing).** Monitor environmental effects on waterways and groundwater of low-level contamination via long-term data collection. Use catch basins for dilution and holding of toxic heat transfer fluids.

* See page 12, 14 infra.
** See page 17 infra.

TABLE I
POTENTIAL ENVIRONMENTAL CONCERNS (Continued)

POTENTIAL ENVIRONMENTAL CONCERNS	STRATEGIES TO MINIMIZE OR ELIMINATE CONCERN
C. Potential Land Use Impacts	
1. Zoning and Solar Access	Utilize local zoning and planning procedures.
D. Potential Ecological Impacts	
1. Air Quality in Living Spaces	Employ proper system design. Follow IPC and MPS materials requirements.
E. Potential Structural Impacts	
1. Risk of Credible Accidents	Adhere to IPC and MPS standards for thermal stress issues and load requirements for hail, snow, wind, and seismic loads.
a. Design loads	
b. Glass breakage	Fence, screen, and shelter collector system from public for safety and from possible vandalism. Use heat tempered glazing and develop less hazardous nonglass glazi through research.
c. Glare	Proper placement of collectors. Paint glare-causing surfaces with nonreflective coatings.
d. Maintenance, installation, and design	Use proper designs for safe maintenance and installation. Provide a detailed installation, operation, and maintenance manual with each solar system. Utilize proper clothing and equipment by working personnel to minim health hazards.
2. Sheltered Areas	Use screening and sealing on all sheltered areas (including ductwor where necessary.

TABLE I
POTENTIAL ENVIRONMENTAL CONCERNS (Continued)

POTENTIAL ENVIRONMENTAL CONCERNS	STRATEGIES TO MINIMIZE OR ELIMINATE CONCERN
F. <u>Aesthetic Impacts</u>	
1. Design	Place collectors on ground sites. Use shields to conceal structures.
G. <u>Social and Institutional Impacts</u>	Emphasize political concern, institutional cooperation, and citizen action group activities.
H. <u>Material Resource Requirements Impacts</u>	Select efficient systems. Recycle and conserve materials utilized. Explore inexpensive, available, and innovative construction materials.

III. POTENTIAL ENVIRONMENTAL IMPACTS

The Solar in Federal Buildings Demonstration Program (under Section 432.76(b) of the Proposed Rule) requires each agency to provide in its proposal an assurance of compliance with: (1) the IPC and MPS standards and performance criteria, where applicable; (2) data in accordance with ASHRAE 93-77 (Method of Testing to Determine the Thermal Performance of Solar Collectors), which is a uniform method of conducting and reporting collector thermal performance test results; and (3) the test procedure (identified in Section 7.2 of NBS Interim Report 78-1305A) for obtaining solar energy reliability and durability test data, based on exposure to natural environments. By requiring compliance with these standards and criteria, the Program will assure that relevant environmental and safety issues are addressed and appropriate strategies to mitigate or eliminate them are followed. The following subsections discuss potential environmental impact areas associated with solar energy applications (see also Table I), as well as specific designs or measures to minimize or eliminate such potential problems.

A. Potential Air Quality Impacts

1. Outgassing

a. Insulation/Fire

If solar collectors overheat due to stagnant conditions caused by power system failure or removal of heat transfer fluid, organic chemical compounds which are often present in the insulation materials or result from their degradation may be discharged. This phenomenon is known as "outgassing." Its occurrence is often evidenced by a thin film (coating) of condensable products on the collector glazing. The presence of this film may be an indication of performance degradation. Upon seeing this film, maintenance personnel should promptly take proper corrective procedures. Most fumes released during outgassing are simple starches that are used as binders for many inorganic insulation materials (e.g., fiberglass). Outgassing impacts are minimized due to containment within the collector unit or, if vented, due to rapid atmospheric dilution and the dispersed locations of collectors. Based upon available empirical data, it is not believed that fumes from outgassing during stagnation periods constitute a significant health problem.

Outgassing could only become a serious concern under fire conditions involving the total building. In this extreme and unlikely situation, temperatures could become high enough to degrade plastics and synthetics, releasing toxic and irritating fumes. As in any extreme fire condition, the entire building structure could pose a safety threat to firefighters and occupants. Firefighters may have to use self-contained oxygen equipment. Persons in the general area can avoid potential fume and fire dangers by responding promptly to alarms and evacuating the immediate vicinity of the building.

b. Mitigating measures

There are already a number of fire safety provisions in the IPC and MPS relating to insulation. Insulation uses are covered by appropriate standards either already in existence or as set forth in the IPC (Section 4.3) and the MPS (Sections S-515-11, S-607-3). Fire resistance of building structures is also covered by the appropriate IPC and MPS sections.

Potential dangers of outgassing from solar collectors due to stagnant conditions can be prevented by proper system design and materials selection. This involves the selection of insulation materials which will exhibit thermal and chemical stability at maximum collector temperatures as measured during stagnant or "no-flow" conditions. In addition, certain types of insulation may be pretreated before being installed in collectors. This pretreatment involves the heating of the insulation to expel volatile materials. The upper temperature limit for fire resistance of fiberglass insulation with organic binders may also be somewhat increased as a result of such pretreatment.

The National Solar Heating and Cooling Demonstration Program experience data reinforce the conclusion that the problem of potential outgassing can be dealt with by using appropriate procedures. Procedures recommended by the Project Experience Handbook[11] include:

- ensuring that collector structures can withstand stagnation temperatures when a building is not in use due to power failure, lack of occupancy, or construction activities;
- checking prior to operation for outgassing of inorganic materials fogging collector glazing;
- if necessary, protecting collectors against high stagnation temperatures which may occur following installation but before startup. To minimize possible stagnation damage, scheduling installation to occur shortly before system turn-on;
- evaluating insulation for collectors to ensure that it will be free from swelling during stagnant conditions; and,
- choosing a collector with an absorber plate coating suitable to withstand protracted stagnation conditions.

In summary, appropriate system design, proper selection, pretreatment (when possible) and testing of materials, and implementation of adequate safety measures (e.g., smoke detectors and fire alarms) and procedures should significantly reduce the possibility of potential outgassing impacts. Correct labeling of system materials and strict adherence to manufacturers' installation guidelines will help assure the success of this approach. When these actions are taken, potential adverse impacts due to outgassing should be minimized. The site-specific and dispersed nature of this Program will further diminish potential outgassing problems. As an integral part of its project review process, the Program shall evaluate specific actions and require assurances by applicants to mitigate or eliminate any potential environmental problems, including outgassing.

2. Auxiliary Unit Emissions

The normal operation of a solar heating and cooling system is not expected to significantly affect local air quality. Under the present state-of-the-art, solar energy systems will, however, typically require the presence of a backup system. The operation of a gas-fired or oil-fired backup system in a building will result in the usual atmospheric emissions associated with the burning of these fossil fuels. However, emissions will be less than those associated with conventional systems as they will be used only as a supplemental energy source. These decentralized emissions will not occur if electricity is used at the solar energy system site for backup purposes; rather, centralized emissions will occur at the power plant site. Again the emissions will be less than those resulting from systems providing complete electrical needs. Potential air quality impacts should be mitigated even further if proper design and control measures are employed (as referenced in the preceding paragraphs and as required for compliance with the Proposed Rule). Moreover, due to the site-specific and dispersed nature of the Solar in Federal Buildings Demonstration Program, potential auxiliary unit emission impacts will be further diminished.

B. Potential Water Quality Impacts

1. Potable Water Contamination

a. Systems

A primary concern in solar system design is to avoid or eliminate potential health impacts related to heating potable water (drinking water). The heat transfer fluids themselves (e.g., glycol fluids) or, in a water-based system, the various additives used as corrosion inhibitors, pH controllers, freeze protectants, and bactericides, could potentially contaminate water supplies and pose a health hazard if proper precautions, as specifically required by the Program through incorporation of the IPC and MPS standards, are not followed. DOE is also sponsoring research to determine how a potable water system could be contaminated by a heat transfer fluid and to determine the toxic characteristics of various typical heat transfer fluids.[12] In addition, research and development is ongoing to develop nontoxic inhibitors and protectants.[13] Results from these ongoing studies should be available in the near future.

The solar system heat transfer fluid typically heats potable water through a heat exchanger. Solar energy systems using liquid and/or air as heat transport media may require one or more heat exchangers. These are used to transfer heat between two different media while preventing mixing or contamination of one by the other. Several types of heat exchangers are available to fill the needs of the various applications.

Equipment and design standards have been established for potable water systems and space heating systems through criteria set out in the IPC and the MPS. Adherence to these standards is required by the Program. It is critical to the efficient operation of a solar energy system that the heat exchangers are correctly sized for specific site requirements before making a selection of the heat exchanger. Solar energy systems using a nonpotable fluid must incorporate a double wall heat exchanger (or protection which provides equivalent safety), as required in the IPC (Section 4.6.2) and MPS (Section S-515-9.1). A single wall heat exchanger would not be acceptable (even if fabricated with extra thick material).[11]

b. ystem additives

Chromates, dichromates, nitrites, nitrates, and ethylene glycol are examples of additives to heat transfer fluids that can be potentially hazardous if proper design and heat transfer fluid requirements contained in the IPC (Chapter 2 and Section 4.4) and MPS (Sections S-515-8, S-615-8, S-615-9, S-615-10) are not followed. Also, leakage of these fluids may occur as a result of system failures. Leakage of heat transfer fluids could contaminate natural water supplies as well as the system potable water supply. Compliance with the appropriate IPC and MPS standards, as required by the Program, requires the use of double-walled heat exchangers (or protection which provides equivalent safety) and continued monitoring (as required by Section 436.80 of the Proposed Rule). Adherence to these standards will minimize or eliminate potential adverse environmental impacts of toxic and potentially toxic additives.

Nontoxic fluids and additives are also being investigated for solar energy system use. Research and development work is underway with the goal of developing effective, nontoxic, and inexpensive heat transfer fluids. This work has been reported in DOE's Solar Heating and Cooling Research and Development Project Summaries.[13]

c. Storage media

Thermal storage media may include molten salts, organic waxes, or plastic/paraffin capsules for liquid systems, and rocks, metal fillings, silica gel, or ceramics for air systems. Leakage control can be facilitated by proper design and adherence to required test criteria set forth in the MPS (Sections S-515-7, S-601-12). A current DOE study is designed to identify solar energy system materials, including storage media, and publish a list of acceptable materials.[14] Compliance with the MPS criteria, including prudent management and adequate monitoring, should minimize or eliminate potential adverse impacts related to storage media.

d. Mitigating measures

A number of required Program measures to guard against potential leakage and potable water contamination are set forth in the IPC and the MPS. These include:

- separation of circulation loops between nonpotable heat transfer fluids and the domestic potable water system;
- identification of nonpotable fluid and potable water systems by color and coded piping or metal tags; and,

- proper double wall heat exchanger systems that provide a high degree of protection against potable water contamination when toxic fluids are used.

The following design suggestions are derived from program experience in order to avoid difficulties identified in earlier demonstration projects. Solar energy systems using a nonpotable fluid must incorporate a double wall heat exchanger, as required in the IPC, except under the following conditions:[11]

- the fluid is certified as nontoxic by FDA, USDA, or HEW. Concentrations must not exceed acceptable levels;
- the system is properly tagged with a warning concerning the use of toxic antifreeze and that servicing (IPC Sections 6.3.1, 6.3.2) be performed by a "trained HVAC service technician or a qualified plumber, each using a service manual";
- the local building and health authorities specifically approve this aspect of the solar energy system (local building and health officials should approve any other proposed solutions before they are implemented); and,
- backflow prevention (IPC Section 4.6.3) is installed.

Compliance with the IPC and the MPS standards, as required by the Program, shall minimize or eliminate the risk of potential potable water contamination, thereby ensuring safe water quality.

2. System Flushing and Disposal

a. Heat transfer fluids

Many of the heat transfer fluids (such as metal oxides and ethylene glycol) used in solar hot water and solar heating and cooling systems will degrade over time. Therefore, these fluids will have to be periodically flushed and replaced. This procedure is typically performed every three to five years as a part of an operations and maintenance program. The disposal of these fluids into local water bodies could adversely affect aquatic life as well as prove harmful to man if such water bodies are used as sources of drinking water. The Program provides specific standards, discussed below under mitigating measures, to ensure that improper disposal does not occur.

DOE is funding research to determine the toxic characteristics of various heat transfer fluids.[12,14] Research and development is also ongoing to develop nontoxic inhibitors and protectants.[13] Additionally, in an increasing number of jurisdictions, the disposal of hazardous chemicals into local water bodies is prohibited. The Clean Water Act and the Safe Drinking Water Act, administered by EPA, regulate improper disposal of pollutants into navigable waters and aquifers.

b. Storage media

For materials most commonly used as storage media (e.g., water, rocks, masonry), the environmental impacts are insignificant and easily handled by landfill methods.[12] Storage media which utilize a phase change (solid to liquid) have not been widely used and it does not appear that they will be used in quantities large enough to cause significant environmental impacts.[12] Also, a DOE study is examining methods of disposal and recycling of hazardous wastes from solar heating and cooling systems.[14]

c. Mitigating measures

IPC (Section 4.4) and MPS (Section S-615-9) standards, which are incorporated as an integral part of the Program, set forth waste flushing and disposal methods for solar energy systems utilizing a heat transfer fluid other than air or potable water. The system must provide for the catchment and/or harmless removal of these fluids from vents, drains, or recharge points as approved by local administrative code authority. The MPS specifically require adequately sized and protected receptacles (including catch basins) when toxic and/or combustible fluids are used, in order to collect and store the overflow from pressure relief valves, liquids drained from the system during servicing, and identifiable leakage. A catch basin will serve to hold a flushed heat transfer fluid during system repairs or until it can be disposed of in an environmentally acceptable manner. It is also anticipated that hazardous waste disposal will be further regulated by hazardous waste disposal standards set pursuant to the Resource Conservation and Recovery Act.

Several ongoing studies are also being conducted to assess the effect of toxic fluids on potable water, sewage treatment facilities, soil, vegetation, and groundwater. These include:

<u>Solar Heating and Cooling Waste Disposal Impact</u> (Sandia Laboratories. Presently being completed);

<u>Hazardous Properties and Environmental Effects of Materials Used in Solar Heating and Cooling Technologies</u> (Sandia Laboratories. Several interim hand-

books will appear on this subject with final publication estimated for August 1980);

Potential Effects of Solar Heating and Cooling Fluids Related to Ecosystems (Los Alamos Scientific Laboratory. Ongoing through FY 1979).

Results of these studies will provide additional data on the potential environmental impacts of solar heating and cooling fluids, additives, and storage media, and progress the state of the art regarding measures to further decrease or to eliminate these potential problems.

C. Potential Land Use Impacts

Buildings using detached solar collectors rather than a rooftop system could require a larger land area than conventionally heated and cooled buildings. Even where actual land area is the same, the need to orient solar energy equipped buildings toward the sun could require alterations and perhaps expansions of traditional lot and street dimensions for subdivisions using solar energy systems. Thus, there is a possibility that increased national use of solar energy systems may alter certain traditional land use patterns and require adjustment of local planning, zoning, and control procedures. Other impacts on land use could result from the requirement of access to sunlight and the preservation of historic sites.

The impacts of solar heating and cooling on land use in the Solar in Federal Buildings Demonstration Program, however, are not expected to be significant. In most cases, solar energy systems will be retrofitted onto existing Federal buildings. In addition, it is not presently anticipated that a large number of detached collectors will be used in this Program. Since solar heating and cooling systems are not significantly different in nature from conventional HVAC systems, they should not impact present land use plans and procedures. Thus, this Program is not expected to conflict with existing or proposed Federal, State, or local land use plans, policies, or controls.

D. Potential Ecological Impacts

a. Air quality in living spaces

Potential ecological impacts associated with solar heating and cooling systems concern the formation of molds and fungi and radon emissions. Fungi spores are a major allergenic pollutant. They typically thrive in a warm, moist atmosphere, such as might be present in rock storage bins or shaded areas between the structure and mounted rooftop collectors. Rock storage systems are generally used with active solar energy systems having air (rather than a liquid) as the heat transfer material. The growth and presence of fungi typically do not exhibit any seasonal pattern but, rather, may be present year round. In the absence of appropriate system design and reasonable maintenance, as required by the Program, the presence of molds and fungi, especially in rock storage bins, could result in their dispersal into building air, thereby posing potential health problems. In addition, studies are being conducted to examine further the potential environmental effects of molds and fungi on air quality in living spaces.[14] Secondly, granite rock heat storage systems may emit radon, a naturally occurring radioactive gas. Current scientific theories[15] focus upon potential problems related to the use of granite rock as a heat storage material. Present studies and data on this potential problem are not conclusive with respect to the nature or extent of this potential health problem attributed to radon released from granite heat storage materials used in solar energy systems. This potential problem can be minimized or eliminated by appropriate system design and storage material selection (discussed below) for the small number of air systems with rock storage expected to be proposed and funded by this Program. Additional studies are being planned to assess further this potential concern.[14]

b. Mitigating measures

Proper system designs can prevent potential mold and fungus growth under rooftop collectors. This typically would involve flush mounting on a watertight membrane. The IPC and MPS guidelines address this in relation to rooftop collector mounting procedures and state that, in general, components and materials used in solar heating, cooling, and hot water systems shall not promote the growth of fungus, mold, or mildew (IPC Section 4.6 and MPS Section S-600-6.7). The presence of fungal growth is to be tested in accordance with Appendix D, Section E, of HUD's Minimum Property Standards (4900.1, 4910.1, and 4920.1).[16,17,18] Application of the appropriate IPC and MPS guidelines will minimize this concern. The Program will provide technical and financial assistance to help ensure that appropriate designs to reduce or eliminate this potential problem are employed. In addition, until the potential concerns about using granite as a heat storage material are resolved, the Program will not allow granite as a heat storage material under the mandatory design review procedures of the Program. This will not affect the Program since alternate types of rock materials are available and may be substituted. Moreover, this procedure allows time for further examination of this potential problem to determine its precise nature and probable impact.

Planning is underway at DOE to monitor all quality conditions in the living or working areas of passive heating demonstration projects.[14] Such research, in addition to the investigation of molds, fungi, and radon exposure levels, will complement existing EPA data on indoor air pollution and help create techniques to further minimize environmental impacts on air quality in living spaces.

E. <u>Potential Structural Impacts</u>

1. Risk of Credible Accidents

a. Design loads

Solar energy systems, in most cases, will involve the placement of collector units on building rooftops. Appropriate design, construction and installation standards, when followed, can reduce potential accident risks for both workers and building inhabitants. Solar collectors could prove to be too heavy for certain roof structures, especially where the collectors are retrofitted. These structures should also be capable of supporting the added weight of maintenance personnel. The Program has adopted specific guidelines (IPC Sections 3.1, 3.2, and MPS Section S-601) pertaining to design loads for rooftop and detached collectors. Careful attention is given to items such as wind, snow, hail, and seismic loads. Compliance with these guidelines would, it is believed, eliminate the risk of credible accidents. The National Bureau of Standards has completed a study of building regulations[19,20] and is continuing this effort through work with DOE and the various code-developing groups to establish guidelines for solar energy applications in buildings, encompassing new and retrofit solar energy systems.[21]

b. Glass breakage

In order to minimize the problem of possible glass breakage, solar collector areas should be fenced, and/or protective covers/screens placed over the collectors in instances where collectors are sited adjacent to public areas. Presently, the hazards of broken glass often are minimized by using heat-tempered glass which "beads" when broken. Research to develop new, durable glazing materials is being conducted by several institutions, including ALTAS Corporation, Hughes Corporation, Research Triangle Corporation, and Springborn Laboratories. The damage history of both glass and nonglass collector glazings will be assessed, and future research will be aimed at developing polymeric and other nonglass collector glazing materials. These efforts should further reduce the potential for glass breakage in solar energy systems. In addition, the IPC (Sections 3.1, 3.2, 5.2) and MPS (Sections S-515-2.2, S-601) address load and thermal stress issues for glazing materials. Compliance with these standards, as required by the Program, should minimize or eliminate any significant glass breakage problems.

c. Glare

Solar radiation reflected from the collector modules can cause localized glare problems. The intensity of this glare will vary according to a number of parameters such as solar intensity, solar angle, solar time, reflectivity of collector covers, frames, and absorption surface, and pitch of roof. The IPC (Section 4.7) and MPS (Section S-303-2) stress that consideration be given to assure that glare does not create unnecessary safety hazards. The glare resulting from flat plate collector modules is expected to be low in intensity and should not cause a significant safety problem if proper design and review procedures are used, as required by the Proposed Rule. Particular care should be taken to minimize or avoid potential hazards to street traffic as a result of unobstructed glare from nearby collectors. Applications of collector coatings which minimize or disperse reflected light will also reduce potential hazards due to glare.

d. Maintenance access

Other safety factors which must be considered are maintenance access to the collector and the proper placement of the collector to prevent impediments to emergency exits. These issues are addressed in the IPC (Sections 4.5, 6.1) and MPS (Sections S-309-1, S-405-6, S-600-6.6). In addition, proper maintenance clothing and equipment, a safety drainage/basin system to drain off and hold any toxic heat transfer fluids in times of repair, installation, maintenance, or flushing, will facilitate safe and efficient maintenance of the solar energy system.

e. Mitigating measures

In addition to the specific standards noted above, IPC (Section 6.2) and the MPS (Section S-600-3) standards, required by the Program, mandate that a detailed installation, operation, and maintenance manual be provided to workers and installers in order to minimize accidents by familiarizing maintenance personnel with the systems. IPC and MPS provisions requiring proper labeling of all solar energy system components, equipment, and hazardous substances (such as certain heat transfer fluids), should also lead to greater safety of maintenance and installation. Compliance with these standards, along with careful system design, should eliminate the risk of credible accidents.

2. Sheltered Areas

Sheltered areas can result from solar collector installations both on rooftops and on the ground. These sheltered areas could potentially become inhabited by vermin, rodents, and birds, possibly creating problems of local infestation. Proper system design and periodic inspection can alleviate these problems. Properly constructed and mounted collectors, possibly with the inclusion of certain types of protective screening, will help ensure that sheltered areas do not become inhabited by undesirable animals. Screening also should be applied to all duct and plumbing outlets to prevent similar problems. Periodic inspections and appropriate follow-up action should eliminate any problems that may occur.

F. Aesthetics

Research and experience indicate that aesthetic considerations are not likely to be a significant barrier to widespread solar energy development. Many architects have found solar energy systems to be compatible with even the most traditional designs for both new and retrofit installations, and a study of early solar energy users by the American Institute of Architects Research Corporation (AIA/RC) concludes that aesthetics appear to be among the least significant potential constraints to solar energy development.[22] Site inspections and DOE/HUD Demonstration Program records indicate that aesthetic considerations have been an issue in only a few cases, and that the issues were satisfactorily resolved in each case.[4]

The visual impacts of solar buildings will depend on the size, type, and location of the collector, and the overall building design. Visual impacts may be aesthetically improved in the future as buildings equipped with solar energy systems become more widespread and exterior designs are refined.

G. Social and Institutional Impacts[4]

Successful solar heating and cooling development must depend heavily upon the cooperation of all involved groups--industry, government, and consumers. Potential social/institutional issues have been identified and evaluated on the basis of research literature, documented experience, solar site visits, and interviews. The following impact areas have been identified as pertinent to solar energy installations:[4] meaningful solar industry standards and product quality controls; availability of investment capital, taxes, insurance, utilities, building codes, zoning and land use controls (including solar access); and interface with existing industry (including labor). The Solar Domestic Policy Review, requested by President Carter, emphasized reliable information, consumer confidence, and quality assurance. This Program should beneficially impact the consumer confidence and quality assurance concerns through safe and practical demonstrations of solar heating and cooling technologies.

Many potential social/institutional concerns result from the relative newness of the technology. These concerns are expected to decrease substantially as existing institutions are exposed to solar energy systems and adapt accordingly. Section 523 (a)(1)(B) of NECPA requires that one of the selection criteria be the "location of demonstration projects in areas where a private sector market for solar energy equipment is likely to develop." This requirement should help provide practical experience and knowledge of solar energy systems, thereby alleviating much of the public unfamiliarity in those areas.

H. Material Resource Requirements

Solar energy system designs will be specific to each site. Thus, it is difficult to assess the types and quantities of materials necessary for construction. Material requirements presented in Table II[23] are approximate figures for a typical baseline solar heating and cooling system. These figures will vary with design and application (conventional auxiliary systems and ductwork are not included). Most materials used in solar energy systems, with the possible exception of copper and chrome, are easily available in sufficient quantity. Due to the small scale of the Solar in Federal Buildings Demonstration Program, solar energy system deployment should not significantly impact the availability of these materials.

IV. RELATIONSHIP TO FEDERAL, STATE, REGIONAL, AND LOCAL LAND USE PLANS AND POLICIES

Site-specific implementation of actual projects under the Solar in Federal Buildings Demonstration Program will require compliance with existing Federal, State, and local land use, zoning and building regulations concerning solar energy

TABLE II

MATERIAL RESOURCE REQUIREMENTS
BASELINE SOLAR HEATING AND COOLING SYSTEM[23]

FLAT PLATE COLLECTOR[a]	
Steel	69.64 lbs (31.65 kg)
Glass	31.80 lbs (14.45 kg)
Aluminum	10.13 lbs (4.60 kg)
Copper Tubing	6.80 lbs (3.09 kg)
Insulation (Fiberglass)	5.25 lbs (2.39 kg)
Miscellaneous	3.00 lbs (1.36 kg)
THERMAL STORAGE TANK[b]	
Steel	1,235 lbs (561 kg)
Insulation (Foam)	$\sim$26 lbs ($\sim$12 kg)
HEAT EXCHANGERS	
Copper Tubing	$\sim$50 lbs ($\sim$23 kg)
ABSORPTION AIR CONDITIONER[c]	
LiBr Solution	80-90 lbs (36-41 kg)
Steel	700-750 lbs (318-341 kg)
Copper	$\sim$30 lbs ($\sim$14 kg)
Stainless Steel	$\sim$18 lbs ($\sim$ 8 kg)
WET COOLING TOWER[d]	
Steel	323-362 lbs (147-165 kg)
Stainless Steel	3-4 lbs ($\sim$1.6 kg)
Zinc	14-16 lbs (6.4-7.3 kg)
Asbestos	60-68 lbs (27-31 kg)

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[a] Based on one 6' x 3' x 6" (1.8 m x 0.9 m x 15 cm) modular panel manufactured by the Honeywell Corp. Collector square footage should be from 1/3 to 1/2 the building square footage.

[b] 1,000 gallon (3,790 litre) capacity manufactured by the Buffalo Tank Company.

[c] 3-ton (2.7-metric-ton) unit manufactured by Arkla Industries.

[d] Appropriate sized unit manufactured by Marley Cooling Towers.

applications and installations. Most of these systems will be retrofitted. Therefore, it is not anticipated that there will be any conflicts with existing or proposed Federal, State, or local land use policies, plans, or controls. Additional experience gained by local officials as they interact with other agency officials and design engineers through project implementation should accelerate the pace at which local officials can accommodate solar energy technologies and applications.

V. POTENTIAL CUMULATIVE AND LONG-TERM ENVIRONMENTAL EFFECTS

With the Nation's growing energy requirements and the finite availability of nonrenewable resources, the need to implement programs of this type is self-evident. Although it is not presently possible to state resultant energy savings attributable to this Program, it is clear that solar installations can reduce the consumption of our nonrenewable energy resources. Through proper design practices, updated standards and criteria, and other environmental and performance data developed as a result of the implementation of this Program, it is believed that the Solar in Federal Buildings Demonstration Program will have a long-term, cumulative, beneficial impact on the natural environment, while also accelerating the development of solar energy and the utilization of renewable resources.

VI. OFFSETTING CONSIDERATIONS

As detailed, the probability of adverse environmental impacts is minimal for all potential impact categories, because of the discrete, highly controlled nature of the Program and the adherence to specific environmental and safety standards. Since it is believed that there will be no probable adverse environmental impacts if applicable standards are followed, an assessment of offsetting considerations is not necessary.

VII. DESCRIPTION OF ALTERNATIVES TO THE PROPOSED ACTION

The purposes of the Solar in Federal Buildings Demonstration Program are to support efforts to shift from nonrenewable to renewable energy sources, to stimulate the solar energy industry, to encourage the continued development and refinement of solar energy technologies, and to assert the leadership role of the Federal government in promoting widespread use of technically and economically feasible solar technologies. Congress has mandated that DOE demonstrate the reliability and practicality of solar energy for space heating and cooling and solar water heating by installing solar energy systems in selected Federal buildings.

A. Other Technologies

Since the expressed purpose of this Program is to demonstrate solar heating and cooling technologies in Federal buildings, reasonable alternatives to this Program do not include intermixing other technologies such as nuclear, fossil fuel, hydroelectric, or wind power strategies. These programs would generate relatively little useful information about solar energy technologies and would not enhance the Congressional purposes underlying this Program. Moreover, the Federal investment in this solar energy demonstration program is not large enough to impinge upon or inhibit other Federal efforts to develop nuclear, fossil fuel, hydroelectric, or wind energy systems.

B. Conservation Strategies

Conservation can decrease but cannot eliminate the demand for energy. With ever increasing energy needs and the finite availability of nonrenewable resources, the need to develop renewable resources is increasing. Therefore, conservation programs alone cannot be considered as a reasonable alternative to solar energy programs. In fact, both strategies are complementary and should be implemented simultaneously. The implementation of the Solar in Federal Buildings Demonstration Program would further the nation's goal of increasing utilization of renewable energy sources.

C. No-Action Alternative

The "no-action" alternative would result in the continued use of electric and fossil fuel power for space heating and cooling and water heating in Federal buildings. An arguable advantage of the "no-action" alternative is that no changes to the existing heating and cooling systems would be made; thus, neither structural changes to the building would be required nor additional costs incurred for the changes. The disadvantages would be escalating fuel and operating costs, increasing pollutant emissions and environmental damage, and a continuing reliance on nonrenewable energy sources. The "no-action" alternative would not aid in achieving the goal of increasing the use of renewable resources and would not encourage the development and use of solar energy systems.

D. Reduced Program Funding

An alternative to this Program would be a program of a lesser magnitude brought about by a reduced funding level. If Program funding were significantly reduced, the market impact on solar collector production would fall well below the 5% to 10% market impact that is anticipated through present funding. Reduced funding would also result in fewer demonstration projects and reduced capability for establishing a significant project experience and a "lessons learned" data base for future solar energy development. In general, reduced funding levels will diminish market penetration, public exposure, and project experience at a time when public acceptance and rapid developments in solar energy technologies are urgently needed.

E. Increased Program Funding

Increased funding levels could result in the expansion of the Solar in Federal Buildings Demonstration Program. This would increase the ability to establish a larger experience data base through more demonstration projects. In the event of the expansion of the Program, additional monitoring controls would be required as well as additional personnel. This alternative would require Congressional approval through increased appropriations.

F. Amended Legislation

One form of legislative amendment would be expansion of the Program to include the application of solar technologies in state and local government buildings. The inclusion of state and local government buildings in this Program would increase the visibility of solar applications and initiate additional projects. This type of expansion would, however, require additional funding for personnel, monitoring and implementation, and overall program administration.

A second possible alternative would be to amend the legislation to require that all new Federal buildings must be designed to take full advantage of solar applications/technologies, wherever feasible. This requirement would increase the number of solar applications in new buildings and expand the opportunities for Federal agencies to gain actual solar experience. An amendment such as this would, however, place additional burdens upon the individual agency budgets, personnel, and workloads. Also, a coordinating effort would be needed to maximize the exchange of solar information between the various agency applications.

In summary, amendments to the legislation as set forth above would increase the visibility of solar technologies due to the variety of size, location, and types of projects. These experiences and project applications would be easily applicable to the private sector. Such amendments would, however, require that additional funding and personnel be added to the existing Program. Amendment of this legislation may also necessitate the adjustment of other energy program activities. Therefore, any such action should be considered in the context of the overall effort toward more effective energy utilization.

G. Unreasonable Alternatives

Additional alternatives to the proposed action were considered and examined but rejected as unreasonable. An example of such an unreasonable alternative would be to delay implementation of the Program. Though this would allow additional time for planning, analysis, and coordination, it would conflict with the legislative mandate. The overriding national need to develop and implement renewable energy resources implies that programs such as the Solar in Federal Buildings Demonstration Program be commenced as quickly as possible. It was therefore determined that it would be unreasonable to delay the implementation of the Program.

VIII. SUMMARY AND RECOMMENDATION

Based on the foregoing analysis, the facts show that the potential environmental impacts are minimal for all potential impact categories. There are no known potential adverse environmental impacts which cannot be avoided by proper design techniques and adherence to the Program standards. Recent developments in solar energy technologies resulting from the National Solar Heating and Cooling Demonstration Program are improving both the performance and the reliability of solar energy systems. Project experience, adherence to the Program Standards, continuing research, and application of the current state-of-the-art techniques, as well as the small scale and decentralized nature of the Solar in Federal Buildings Demonstration Program, should minimize or eliminate any potential incremental adverse environmental impacts which may arise in connection with this Program.

Based upon the foregoing considerations, which included detailed analysis and demonstrations of relevant areas of environmental concern, it is believed that the Solar in Federal Buildings Demonstration Program does not represent a major Federal action significantly affecting the quality of the human environment, as defined in connection with Section 102(2)(c) of the National Environmental Policy Act, as amended. Thus, it is recommended that a negative determination be prepared to certify that an environmental impact statement is not required for the proposed action.

FOOTNOTES AND ADDITIONAL REFERENCES

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11. National Solar Heating and Cooling Demonstration Program Project Experience Handbook, (preliminary draft), DOE/CS-0045/D, U.S. Department of Energy, Assistant Secretary for Conservation and Solar Applications, Office of Solar Applications (copies available from the National Technical Information Service, NTIS# DOE/CS-0045/D).

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